A Collaborative, User-Producer, Assessment of Earthquake Response Products

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Summary

The US Geological Survey (USGS) and Washington State Emergency Management Division (EMD) conducted a 3-phase project to learn about the needs of emergency managers, and how well USGS Earthquake Hazards Program (EHP) earthquake response products met their needs.

In the first phase, the project team held focus group meetings with emergency managers at the county and local levels, State agencies from Washington State, and with two private companies. These meetings revealed that earthquake response products have not met some important needs of emergency managers at the county and local levels. Particular reasons for this include: 1) many emergency managers and their constituents are unaware of most earthquake products; 2) the scale of map products is not suitable to local needs; 3) products need to convey impact on the built environment and social systems more tangibly and clearly; 4) everyday language needs to be used, and technical information provided only when necessary, 5) emergency managers' confidence in instrumental measurements needs to be raised to the same level as that which they have in eyewitness observations.

In the second phase the USGS-EMD project team developed new prototype products that attempted to address the needs revealed in the first phase. These new products were explained and marketed to participants in the regional 2012 Evergreen Earthquake Exercise.

The final phase was meant to test the efficacy of the prototype USGS-EMD products, by observing the Exercise at the participating Emergency Operation Centers. Some aspects of the Exercise turned out to make it particularly poorly suited for the purposes of testing USGS-EMD or EHP products, but valuable lessons were learned nonetheless. Among these were: 1) after the first few hours following an earthquake USGS-EMD and EHP products are consider unnecessary by most emergency responders; 2) a significant fraction of personnel engaged in emergency response during crises are drawn from many sectors of the community, increasing the breadth of needed education and marketing; 3) information conveyed via formats other than maps should be considered, as maps are not used by many emergency personnel; 4) information exchange, archiving, and analysis involves happens via a wide range of mechanisms and technical capabilities vary significantly from one emergency management agency to another, implying that widely used products must be easily accessed and employed.

Introduction

The USGS Earthquake Hazard Program (EHP) has the statutory responsibility under Public Law 108-360 within the National Earthquake Hazards Reduction Program, to "Operate a National Seismic System" and "Work with officials of State and local governments to ensure that they are knowledgeable about the specific seismic risks in their areas." As is sometimes the case with agencies or individuals focused on addressing immediate societal needs, some EHP products have been developed with the goal of addressing only perceived, rather than truly known, needs. Moreover, needs and capabilities may change with time, warranting updates of assessments of products' efficacies. Table 1 lists and describes the EHP products meant to fulfill the USGS's statutory responsibilities by providing the information needed for effective earthquake response at the State and local levels.

A key user group of EHP products is the emergency management community at state and local levels. However, the EHP has not assessed or verified the fulfillment of their needs by directly polling these intended beneficiaries. Several examples highlight the

importance of this direct polling. Wald et al. (2011) note that alerting systems for other types of disasters were evaluated and found ineffective because they did not meet user needs to know the likely impacts of the disaster (e.g., for pandemic diseases by World Health Organization, and terrorism by US Department of Homeland Security). In their study of state and local emergency response to hurricanes, Lindell et al. (2007) note the importance of developing response tools grounded in a clear understanding of responders needs and state that "the development of these decision support systems will provide a critical foundation for evacuation decisions, but the development of such tools must be guided by a better understanding of the context in which these decisions are made at the state and local levels". Herein, we describe results of the a project in which we sought to learn directly from emergency managers at the state, county, city and other local levels about their needs and how EHP products addressed those needs.

Another goal of the project was to test the hypothesis that activities and products developed collaboratively, by users and providers, will more effectively meet user needs. Experiences of the US Army Corp of Engineers provide support for this hypothesis, summarized in a paper describing changes to how they address their mandate to facilitate disaster response and recovery (Hecker et al. 2000). For example, Hecker et al. note "the Corps has learned the significant need for and value of ''peacetime'' planning and partnering with our counterpart state and local agencies. Through these partnerships we are better prepared to ''seamlessly'' augment their efforts in the public works and engineering aspects of response and recovery". Our project team members include both providers from the USGS EHP office in the Pacific Northwest and users from the Washington State Emergency Management Division (EMD). Our experience working together as an EMD-USGS team on the first, information-gathering phase has permitted us to reach out to and learn from current and potential users in more efficient and informative ways than had we worked alone. For example, EMD personnel have much greater awareness than USGS personnel of the potential users in the emergency management communities, particularly at the local level. This paper documents some of this teamwork and evidence of its benefits.

Anecdotal evidence from EHP personnel in other regions and the institutions that comprise the Advanced National Seismic System (ANSS), the umbrella structure for earthquake monitoring in the US and is managed by the USGS, suggest that emergency management departments' use of EHP products ranges from significant use to complete unawareness. The evidence we have gathered in this study indicates Washington State emergency management departments' usages span a comparable range. Some of this evidence comes from USGS personnel serving as observers during earthquake exercises, or their direct conversations with emergency managers. A published report about the major 2008 "Great Southern California ShakeOut" earthquake drill describes new EHP products generated specifically for the exercise (Jones and Benthien 2011), but makes no mention of use of exercise-versions of existing EHP notification or response products (Table 1). USGS personnel in the Pacific Northwest have observed and participated in earthquake exercises conducted by emergency management departments. These experiences clearly demonstrated that, despite having provided exercise-versions of products, even the technically sophisticated departments did not use them. This study attempts to answer the question 'why not?' The Puget Sound region-wide, 2012 Evergreen Earthquake Exercise Series presented an ideal opportunity to learn directly from state, county and local level emergency managers and to test some new collaboratively developed products. The Evergreen Exercise focused on coordination among the Federal Emergency Management Agency (FEMA), the Washington State EMD and their State Agency Liaisons, seven Puget Sound county departments of emergency management and their local constituents. Project results will form the basis of recommendations for changes to EHP products that will enhance the effectiveness of both the EHP and emergency managers.

A Strategy for Assessing and Improving Earthquake Products for Emergency Managers

The goal of this first project phase was to assess directly the awareness and usage of EHP products by emergency managers. We accomplished this by hosting focus group listening sessions (see Peek and Fothergill (2009) and references therein) with seven of

the eight counties participating in the Evergreen Exercise, one session with the State Agency Liaisons (employees responsible for emergency preparedness and response in the Washington State Departments of Corrections, Commerce, Transportation, General Administration, Labor and Industries and the Red Cross), and one with several large private companies (Liberty Mutual Insurance and T-Mobile). The eighth county participating in the Evergreen Exercise chose to provide input only as written answers to the discussion questions we provided. As described in later sections of this paper, the information gathered at these sessions revealed that some needs were being met and others were not. The information was used to identify and develop several new products for the Evergreen Exercise that we attempted to be evaluated during the Exercise. These were developed and implemented collaboratively, by the USGS and Washington State EMD together (referred to as USGS-EMD products). The final results of this project will be communicated to broader communities, within the USGS, and among emergency managers, with the goal of affecting long-lasting change.

Focus Group Goals and Format

The use of focus groups for gathering input is well established (Peek and Fothergill 2009). The goal of the focus group sessions we conducted was to listen and learn from county emergency managers and their constituents. Each session was initiated with a request to the director or another employee of the county department of emergency management, who assumed responsibility for recruiting participants. In this way participants were more likely to be 'key informants', those with strong connections to the business of post-earthquake emergency response, than if we had recruited participants ourselves (Peek and Fothergill 2009). Sessions were held at county emergency management facilities, involving between three participants for the private sector session to 28 in the largest group and included men and women. Participants included county, city, and local emergency management agency employees, firemen and police, public utility workers, emergency planners for medical facilities and schools, and others. Most participants had experience responding to a few small felt earthquakes and perhaps half the participants to the 2001 M6.8 Nisqually earthquake, which was the most recent

damaging earthquake to impact the region. We provided a list of 'warm-up questions' questions that was circulated to all invitees both before the group meeting and used to guide discussion during each session. Both authors led most of the sessions, although in a few cases just one of us moderated. Each session lasted approximately 90 minutes, and participants generally were engaged and expressive. We took written notes during each session, summarized them, requested corrections from session participants, and shared final drafts with participants from all the sessions.

Focus group questions were organized in the time sequence of a real earthquake occurrence, from notification, gathering situational awareness, and distributing information. This organization seemed like the most logical way to help participants organize their thoughts. We began with questions about notification that an earthquake had occurred. Examples of the most general questions include, "How would you be notified that an earthquake has happened? What information do you need to be able to respond?". Then we asked about information gathering, such as "How is information communicated, integrated, tracked, archived, and displayed? How do you assess what and where the impacts are most significant and then prioritize those needs?". These were followed by questions about distribution of information, e.g., to whom and how? Finally, some general questions were posed, such as "What did your agency glean from the 2001 M6.8 Nisqually earthquake? What additional training would improve your response to earthquakes?". We concluded with an open discussion with participants addressing any comments or questions they had about products and services currently provided by the Washington EMD and USGS.

We did not follow a strict protocol for gathering information, and while the same questions were used to guide each session, we intentionally allowed discussions to be participant-driven. Thus the level of detail and topics covered varied among the groups. The level of detail recorded also varied both within individual sessions and among them. For these reasons we did not perform any formal analyses on the information gathered at the focus group sessions, such as methods involving 'coding' of themes and analysis of codes (Peek and Fothergill 2009), and do not to convey results quantitatively (e.g. in

terms of percentages of responses). Instead our inferences reflect our own qualitative assessments of common themes and significant lessons. As noted by Merton (1987), further survey or other more quantitative research would be needed to validate rigorously what themes and lessons were truly most common, which is beyond the scope of this project. However, we attempted to draw all inferences from focus group input, rather than our own opinions.

Focus Group Lessons

Users' Scope

Needs and opinions expressed varied significantly from one session to the next, but related with characteristics of the responding county. Surprisingly perhaps, the smaller, more geographically remote and less resource-rich counties seemed more satisfied with the status quo and more focused exclusively on their own jurisdictions. At the other extreme, the two private companies' interest was more focused on a single institution (*i.e.*, their own facilities and operations) than the diversity of groups and needs attended to by emergency managers. However, their interest was also global in geographic extent because of the distribution of their facilities and operations throughout the world.

Notification

Participants indicated five different methods of notification that an earthquake was occurring. Almost universally among the counties and State agencies, the primary earthquake notification method was feeling the ground shake. In many cases this was the only method of notification deemed necessary, justified by the assertion that earthquakes too small or distant to be felt would not require immediate attention. Another commonly cited notification means was receipt of reports of shaking from 911 Call Centers. The two private companies and some county and local personnel received notifications delivered electronically, mostly from the USGS's Earthquake Notification System (ENS, Table 1). A few responders used smart-phone applications. Primarily in the largest

counties or agencies, social media (particularly Twitter) was considered reliable and useful. Twitter users believed erroneous messages were naturally discovered and corrections dispensed, and notification tweets often arrived before television or radio broadcasts. Almost all participants told us that emergency notifications increasingly are received via cell and smart phones and encouraged tailoring and delivering earthquake information via these devices.

Situational Awareness

Situational awareness, "the engine that drives decision making" (Endsley et al. 2003), is key to effective emergency response (McManus et al. 2008). For emergency managers and the private companies this awareness following earthquakes requires tangible metrics of impact (Wald et al. 2011), conveyed in non-technical language and graphics. Response to this within the EHP has been the development of an Earthquake Impact Scale (Wald et al. 2011) and the PAGER (Prompt Assessment for Global Earthquake Response) product for M>5.5 earthquakes (Earle et al. 2009), which provides estimates of the economic loss, fatalities, and population exposed to various potential damage levels. However participants noted that the scale of PAGER information is too large to be useful at the county and local level, particularly for smaller earthquakes. Other available products meant to convey impact and distributed rapidly include USGS ShakeMap, the Did You Feel It?, and ShakeCast (see Table 1). Many counties and both companies were unaware even of the existence of these products (particularly ShakeCast) making concerns about product utility moot! With regards to the products and information they did make use of, such as the USGS website, users noted that they often included overly technical extraneous information. A suggested remedy was the availability of two sets of products, one designed for the general public and the other for more technical audiences such as engineers and scientists.

Key earthquake parameters deemed essential for making decisions about the need to respond include earthquake magnitude and epicenter given as the distance in miles relative to a known geographic landmark. Many people also wanted to know the

earthquake depth, understanding that it might affect the severity of the area impacted. The current EHP products provide these parameters. Everyone felt knowledge of the level of impact of the earthquake in the geographical area where his or her particular facilities were located also was considered key. Participants noted that current EHP products did not convey an easily understood picture of the impacts of earthquakes.

Many of the EHP products are meant to facilitate situational awareness (e.g. ShakeMap, Did You Feel It?, PAGER, ShakeCast; see Table 1). Focus group participants revealed that situational awareness primarily comes from personal reports received from 911 Call Centers, fire and police departments, and what responders often call "windshield surveys", in which they gather damage information by driving through impacted areas and report their observations back to a response center. Widely used situational-awareness information sources include National Oceanic and Atmospheric Administration weather radios, local and regional media, and various websites. Communication of situational-awareness information from the field to emergency operations centers appears to rely heavily on telephone calls. A number of agencies are developing mobile apps for acquisition and delivery of field information and for gathering crowd-sourced observations (i.e., from the general public using electronic media). Amateur radio operators provide an important back-up means of communications in many communities.

No single mechanism of compiling, storing, and conveying information to those needing it could be identified as commonly used. Most institutions use commercial electronic database and mapping systems, with some using these exclusively. Others have built in-house systems to organize, share and display observations using commercial applications like Microsoft's 'Streets and Trips' and 'SharePoint 2010', Google's 'GoogleEarth', or ESRI's 'ArcGIS' (all described on company websites). WebEOC, a real-time web-enabled crisis information management system developed commercially by ESi, is meant to be an official link among public sector emergency managers in Washington State (see <esi911.com/esi/>). While used by many agencies, it always was just one of multiple communication tools. A commonly expressed desire was for a centralized, one-stop shop

for all types of disaster information (e.g., like the Department of Homeland Security's 'Virtual USA'; see < http://www.firstresponder.gov/Pages/VirtualUSA.aspx>), because the abundance of websites and other individual sources of information unique to specific types of emergencies often were overwhelming.

Emergency management focus group participants placed a high value on information verified by human observation to develop post-earthquake situational awareness. They rely on on-site first-hand assessment of impacts when making decisions about if and how to respond. This was also true for the two companies, but to a lesser degree. This need for eyewitness verification contrasts with much of the science underlying the understanding of earthquakes, which relies on inferences derived from remotely made instrumental measurements. Although derived from in situ measurements of actual ground shaking, map products like ShakeMap or Did You Feel It? were sometimes considered only as providing useful overviews or corroboration of common-operating pictures gleaned from other sources. The products are not used as a primary basis for decision-making. This likely reflects an inappropriateness of product scales for use at the local level, challenges integrating the products with familiar mapping and awareness tools, or the perception that a picture relying on a model or interpolation may not be sufficiently accurate. (The choice of scales has been made based somewhat on technical limitations on the spatial resolution of the quantities being mapped, and do meet the needs of users other than county and local emergency managers, e.g. agencies involved with national-scale response to major earthquakes globally.) Many responders were simply unaware that these map products existed. We suggest that a more formalized strategy to raising awareness about EHP products that currently exists would improve their usage significantly.

Perhaps the most unanimous agreement about any issue raised pertained to the utility of receiving estimates of the probability of aftershocks. Emergency managers all stated that even if uncertain, probabilities would be useful for prioritizing and scheduling recovery activities. They also noted that the general public would like to know about aftershock probabilities.

Information Dissemination

EHP products will only be useful if delivered using easily implemented, efficient methods. Mechanisms for distributing information by participants were equally as diverse as those used to gather information. These included reverse 911 systems, amateur radio, WebEOC, SharePoint, commercial voice messaging services, county websites, and intranets, and MyStateUSA (see < http://www.mystateusa.com/>). FEMA's *Regional Catastrophic Preparedness Grant Program* to support development of regional plans in major urban areas is one example that highlights the consensus that a uniform distribution system would be beneficial. More specifically this includes the regional effort to improve regional catastrophic planning and operations the umbrella of the *Puget Sound Regional Catastrophic Planning Program*.

The Testing Phase

Products to Meet Inferred Needs

A primary goal of the first phase of our project was to learn about the needs of county and local emergency managers and the extent to which EHP products address those needs. We learned that some of the products have not met some important needs. This conclusion is based on input gathered during focus group sessions conducted with seven counties the Puget Sound region, Washington State Liaisons to the State EMD, and two private companies. Guided by the insights gleaned for these sessions, the project team identified and developed products meant to address some of the unmet needs. We attempted to test their effectiveness during the Evergreen Exercise in June 2012. Herein we describe these new USGS-EMD products and the lessons learned during the Evergreen Exercise.

In the following list we summarize the needs identified in the assessment phase and the products intended to address them, designed specifically for use and efficacy testing during the Evergreen Exercise.

- Simpler messaging and explanations is needed, and may be achieved by developing two styles of some products, one designed for non-technical users and the other tailored for engineers and scientists. This would allow the user to select the product look and feel to meet their needs. To address this we developed a new, single-page, summary webpage for the non-technical users about the ShakeMaps used to create the scenarios that guided the Exercise (Fig. 1). This webpage described what ShakeMaps are, the various types of ShakeMaps available, and links to tools for downloading them for import into other systems and to other more detailed or technical information.
- Maps need to be at scales useful for county-level response, and have familiar geographic features and infrastructure relevant to response overlain. We developed an expandable online map-viewer, accessed using standard web browsers (Fig. 2). This viewer was built around ESRI's ARC-GIS web map-service, and allowed users to superpose transparent ShakeMaps on a variety of base-maps as well as layers containing various types of infrastructure (e.g. roads). In addition, users could add facilities impacted by the scenario earthquakes to the maps they were viewing (i.e. apparent only on their viewers).
- The tangible impacts of an earthquake must be conveyed more simply and succinctly, employing a scale useful for decision-making at the regional and local levels. We produced a prototype 'Earthquake Impact' page, modeled after the USGS's PAGER product (Fig. 3). The ShakeMap serves as input to a rapidly executed economic loss estimation tool. A one-page Earthquake Impact document conveys impacts in terms of estimated population exposure to various shaking levels and dollar losses to specific counties and cities.
- Increased awareness of what products requires actively marketing products to intended users and regularly reminding users about them. While face-to-face meetings were considered useful, tutorials and seminars delivered electronically were considered most desirable because they required no travel and could be viewed at

users' convenience. Several months prior to the Evergreen Exercise we described EHP products in an hour-long webinars titled "A Practical Guide to Pacific Northwest Earthquakes" attended by ~130 Exercise participants during two showings. The material presented was developed into an online tutorial for individuals, viewable with any web browser (Fig. 4). This and the products described above were demonstrated at the final Exercise planning meeting and advertised by sending emails to all county Emergency Operations Center (EOC) managers and via postings on the official Exercise website and in the Exercise Training Guide.

Another goal of our project was to test the hypothesis that user-provider collaborative activities and product development produces results that more effectively meet user needs. All the aforementioned USGS-EMD products were developed using a collaborative iterative process, in which drafts and changes to materials were passed back and forth between USGS and EMD personnel. This readily revealed mismatches in perceptions of what constitutes understandable language and interesting or useful information, and made it easy to identify specific paths to improve clarity.

Testing during the Evergreen Exercise

To measure the effectiveness of our efforts to market our new USGS-EMD and existing EHP products and the products themselves, we posted observers at all of the participating county EOCs, at the Washington State EOC, and at FEMA Region X's EOC during one of the two Exercise days. We requested that these observers note if and which of the products were used, and what other tools and mechanisms of information exchange were most commonly employed and how effective they were. Observers were geologists or seismologists employed by the USGS or Pacific Northwest Seismic Network at the University of Washington. We summarize observers' common observations and inferences in the following paragraphs, and provide specific observer notes in the Appendix.

Observer reports all led to the same general conclusion, that none of the USGS-EMD or EHP products were used and in most cases, were completely ignored. While this might lead to the conclusion that our strategy and hypotheses were wrong, we conclude instead that the test itself was ill posed. While we were aware from the onset of the project that some aspects of the Exercise were not well suited to our testing goals, we had not appreciated their importance. Other Exercise aspects were a surprise. Thus, in both these regards we learned some valuable lessons. The first fatal flaw in the Exercise for testing purposes turned out to be the fact that the Exercise scenario started one day after the earthquakes occurred (a 'warm start' in emergency management jargon). The Exercise scenario was built around the effectively simultaneous occurrence of 5 major earthquakes in the Puget Sound region. The observers noted that Exercise participants felt that after one-day, information about the causes of the disaster was irrelevant to their task of recovery and sufficient situational awareness had already been gleaned such that products like ShakeMap were no longer useful. In other words, a clear lesson was that the USGS-EMD and EHP products are considered useful only in the very first hours after an earthquake. The second fatal flaw was the lack of aftershocks in the Exercise scenario. This and the warm start effectively eliminated all perceived need for earthquake information. According to the 6 observers, in only two EOCs were any questions about the causative earthquakes asked. Press releases were issued in most of the EOCs, but other than the first ones announcing the occurrence of the disasters, none contained any mention of earthquakes or connections between earthquakes and their impacts.

A third lesson pertains to awareness of USGS-EMD and EHP products and education about them. Most of the personnel staffing the EOCs were there on temporary assignment as liaisons from other widely varied entities. Some were serving at an EOC for the first time. How do we effectively educate such a diversity of participants? In the largest counties' and at the State EOCs, liaisons receive regular training between disasters and these trainings may provide venues for product marketing. In addition, EOC managers educated about products may guide even temporary workers toward using them during real earthquake disasters.

Several other common threads were clear in the observers' reports. Observers all expressed surprise at the lack of reliance on maps, and instead conveyance of information was accomplished via spreadsheets, lists and other non-graphical means. In some EOCs maps showing locations of impacted infrastructure were displayed, but observer perception was that most EOC staff were not using them to do their work. A lesson for product developers may be to present information in a variety of formats and/or to make maps easier to generate, display, and use.

Another common thread among observer reports was the use of a wide variety of procedures and methods for information exchange, archiving, and analysis. Those methods involving computer and networking technologies presented significant challenges to smooth operations at most EOCs. While the State EMD serves as the central clearing house for operations and situational awareness, communications to and from the State EMD were in many cases infrequent and not easily executed. This lack of uniformity in approach and technical capabilities might suggest that to be widely useful, products must require minimal user technical expertise.

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Appendix – Evergreen Exercise Observer Reports

The *Snohomish County* Emergency Management Department is of moderate size, and includes the city of Everett (home of the Boeing Company, although Boeing has its own EMD). This County was among the few where the EOC staff had numerous questions for

the observer about the scenario earthquake and earthquakes generally. Technical difficulties of many sorts were the greatest challenge to EOC operations. Most internal information exchange happened using verbal or paper communications. The EOC manages internal electronic information exchange and archiving using a system built around MicroSoft SharePoint, and which seemed to require significant coddling to be useful. WebEOC was used only for exchanges with the State EOC, and these did not happen very often. Generating situational-awareness maps electronically was very challenging and the first electronically generated map was not available until the afternoon. A ShakeMap was downloaded but difficulties importing it into their own mapping system, due to projection issues, ultimately led to staff abandoning the effort.

The *Kitsap County* Emergency Management Department is one of the region's smaller departments, with the largest facility encompassed by the county being the Kitsap Naval Base (like Boeing, the Navy has its own EMD). Approximately 50 people participated in the Exercise at the EOC. The observer emphasized the complete absence of map usage in EOC operations. The only map displayed showed various impacts of the earthquake to infrastructure, but most information was conveyed and exchanged through lists and tables. The GIS staff person was aware of EHP products but did not use any of them.

The *Washington State* Emergency Management Department displayed maps of the State showing road closures and other impacts, but none containing any geological information. The observer noted that maps were being pulled in from other sources, but "the USGS was not on their radar". The USGS-EMD ShakeMap viewer was tried, but the observer thought it was abandoned because the faults on the ShakeMap obscured other map features of interest. His perception was that many of the people in the EOC were not EMD staff and were self-directed, and that information overload led to an *ad hoc* communications system within the EOC.

The *Thurston County* Emergency Management Department is a moderate-sized EMD, with the County including the city of Olympia. The ShakeMap viewer was displayed in the EOC but no one seemed to have either permission or sufficient interest to add to or

change it. Communications with the State EMD were hampered by challenges with the WebEOC system. The observer noted that no one had any interest in geologic information, and attributed this to the scenario starting one day after the earthquake.

The *Pierce County* Emergency Management Department is a large, relative well-resourced EMD. Pierce County contains the city of Tacoma and extends to Mount Rainier. Approximately 50 people were at the EOC, with many being liaisons from other agencies (*e.g*. the Red Cross, National Guard, etc.). Special sessions demonstrating the USGS-EMD products were conducted for the EOC staff and at an Exercise planning meeting of liaison agencies. Despite the additional marketing before the Exercise, the only product used was a ShakeMap displayed in the very first few hours. An EOC GIS specialist told the Observer that integrating the ShakeMap into their own mapping system was not easy enough to use in a real crisis, and suggested that delivery of map layers would only be useful if received via a web map service. Numerous press releases were generated and only the first one made any mention of an earthquake.

The *FEMA Region X* EOC had approximately 100 people working, with many of these being liaisons from other federal and state agencies. The primary role of the EOC seemed to be directing resources from outside the region, when requested from the State EMD. Large screen displays were shown all around the EOC, containing spreadsheets describing resource requests and flow status, video of mock-news reports (all about impacts), and a regional map with impacted infrastructure overlain. The only EHP product displayed was the live Recent Earthquakes page although no one was paying attention to it (perhaps because it had no relevance to the Exercise scenario!). The ShakeMaps were used in one briefing prepared by the GIS staff for upper management, with a staff member noting that the ShakeMap was “eye-candy”.

Figure Captions

Figure 1. ShakeMap webpage. The webpage was intended to provide Exercise participants with a basic understanding of the ShakeMaps used to design the Exercise scenario and with links to a ShakeMap viewer (Fig. 2) and to more detailed or technical information.

Figure 2. Example view of the online, zoomable ShakeMap viewer. This example shows the ShakeMap for the South Whidbey Island scenario earthquake (colors) as a transparent layer on a basemap with county boundaries, roads, parks and other geographic features. Locations of closures, damaged structures, and operating facilities resulting from the scenario earthquake are shown by the various symbols. The rectangle in the center of the ShakeMap outlines the fault that broke during the earthquake.

Figure 3. Earthquake 'Impact' page. See text for explanation.

Figure 4. First page of online tutorial "A Practical Guide to Earthquakes". This tutorial was made available to all Evergreen Exercise participants prior to the Exercise, with one of the two lessons dedicated to information about EHP products. I can be viewed using any standard web browser.

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Table 1 – Earthquake Hazards Program Response Products

Product & URL (additional information)	**Description**
Earthquake Notification System https://sslearthquake.usgs.gov/ens/	Sends automated, customizable, notifications of earthquakes through e-mail, pager, or cell phone.
ShakeMap http://earthquake.usgs.gov/earthquakes/shakemap/	Automatically generated maps displaying instrumentally measured shaking intensities.
Did You Feel It? http://earthquake.usgs.gov/earthquakes/dyfi/	Map of earthquake affects derived from citizen input via online web-forms.
PAGER http://earthquake.usgs.gov/research/pager/	Prompt Assessment of Global Earthquakes for Response rapidly compares the population exposed to various shaking intensities to estimate likely fatalities and economic losses.
Realtime Earthquake Map http://earthquake.usgs.gov/earthquakes/map/	Automatic maps and event information displayed online within minutes after earthquakes worldwide.
CISN Display http://www.cisn.org/software/cisndisplay.html	Stand-alone application graphically alerts users, in near real-time, of earthquakes and related hazards information.
ShakeCast http://earthquake.usgs.gov/research/software/shakecast/	An application for automated delivery of ShakeMaps and probably damage to specific user-selected facilities.

Please send us feedback! To help us meet our goal of making our products more effective, we'd like to hear about what you found useful about these products and their presentation, and any suggestions for improving them. Please do so by sending email to Joan Gomberg.

ShakeMaps

What are they?

ShakeMaps display earthquake-generated shaking intensities (and likely damage) within minutes, to guide your response.

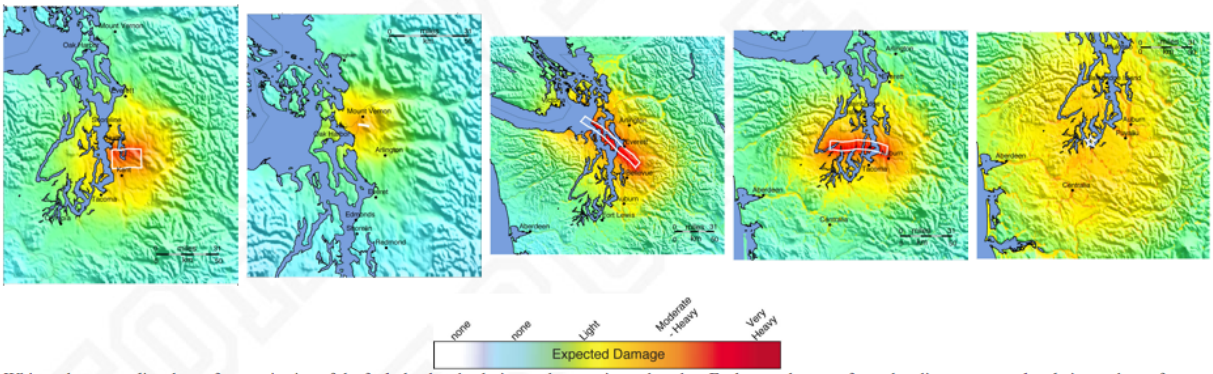
Real earthquake ShakeMaps are derived automatically using sensors deployed regionally. Scenario ShakeMaps for hypothetical earthquakes are derived from computer-models.

More information about ShakeMaps may be found on the original USGS ShakeMap webpage.

2012 Evergreen Earthquake Exercise ShakeMaps

- **View** ShakeMaps in a zoomable online map-viewer, atop geographic features and infrastructure. Click here for instructions on how to use this viewer.
- **Download** a ShakeMaps for use in your own mapping tools
  - Click on the image of the ShakeMap desired and a download page will open.
  - Read about options, or just select *Instrumental Intensity* (what's shown below) in *JPG* format.
- **Learn** more about each scenario earthquake - Click on the title above a ShakeMap image below.

M6.7 Seattle | M5.7 Darrington-Devils Mtn | M7.4 South Whidbey Island | M7.1 Tacoma | M7.2 Olympia-Nisqually



White polygons outline the surface-projection of the fault that breaks during each scenario earthquake. Faults are planar surfaces that dip at some angle relative to the surface, so more vertically-dipping fault traces appear skinnier. The M7.2 Olympia-Nisqually epicenter is shown instead (star) because the earthquake occurs on an unknown fault.

Figure 1. ShakeMap webpage. The webpage was intended to provide Exercise participants with a basic understanding of the ShakeMaps used to design the Exercise scenario and with links to a ShakeMap viewer (Fig. 2) and to more detailed or technical information.

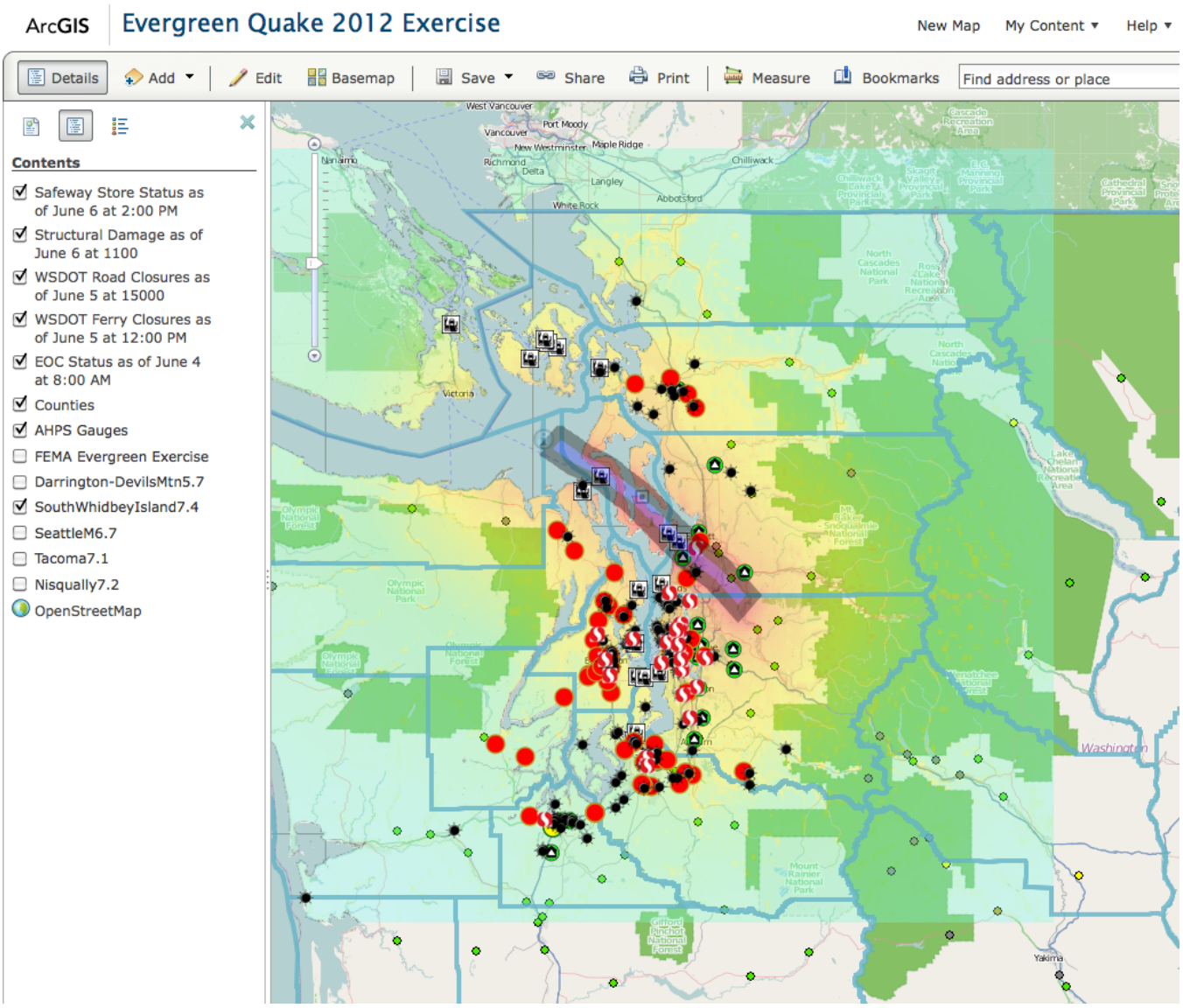
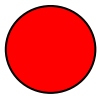


Figure 2. Example view of the online, zoomable ShakeMap viewer. This example shows the ShakeMap for the South Whidbey Island scenario earthquake (colors) as a transparent layer on a basemap with county boundaries, roads, parks and other geographic features. Locations of closures, damaged structures, and operating facilities resulting from the scenario earthquake are shown by the various symbols. The rectangle in the center of the ShakeMap outlines the fault that broke during the earthquake.

USGS science for a changing world

Washington Military Department
Emergency Management Division

Earthquake Impact



Red Alert

M 7.1 TACOMA FAULT SCENARIO

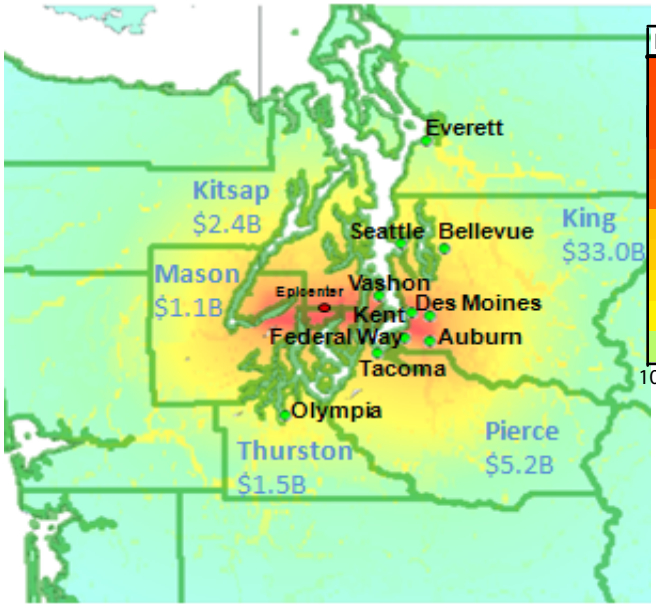
Location: just north of Tacoma, Washington
47.41°N -122.70°W Depth: shallow
Origin Time: 04:00:00 local time

The 'Red Alert' designation for this earthquake indicates estimated total losses would likely exceed 1 billion dollars.
Alert levels of Orange, Yellow, and Green would indicate total losses between 100 million and 1 billion, 1 and 100 million and less than 1 million dollars, respectively.

Estimated Population Exposed to Earthquake Shaking Intensities

SHAKING INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
NUMBER OF PEOPLE EXPOSED to SHAKING INTENSITIES		0	0	20,000	674,000	1,493,000	1,334,000	588,000	173,000	0
EXPECTED DAMAGE (Building Type)	(Sturdy)	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	(Fragile)	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

Shaking Intensity (Potential Damage), Estimated Losses, County Boundaries



Selected City Exposure

Intensity	City	Population
IX	Auburn	46,000
IX	Des Moines	29,000
IX	Kent	82,000
VIII	Federal Way	81,000
VIII	Vashon	11,000
VII	Tacoma	197,000
VII	Bellevue	112,000
VII	Seattle	569,000
VI	Olympia	45,000
V	Everett	97,000

10 most-impacted cities with populations >10,000.

PAGER

DISCLAIMER: Information displayed on this sheet is hypothetical, derived only for use in the 2012 Evergreen Earthquake Exercise.

Figure 3. Earthquake 'Impact' page. See text for explanation.

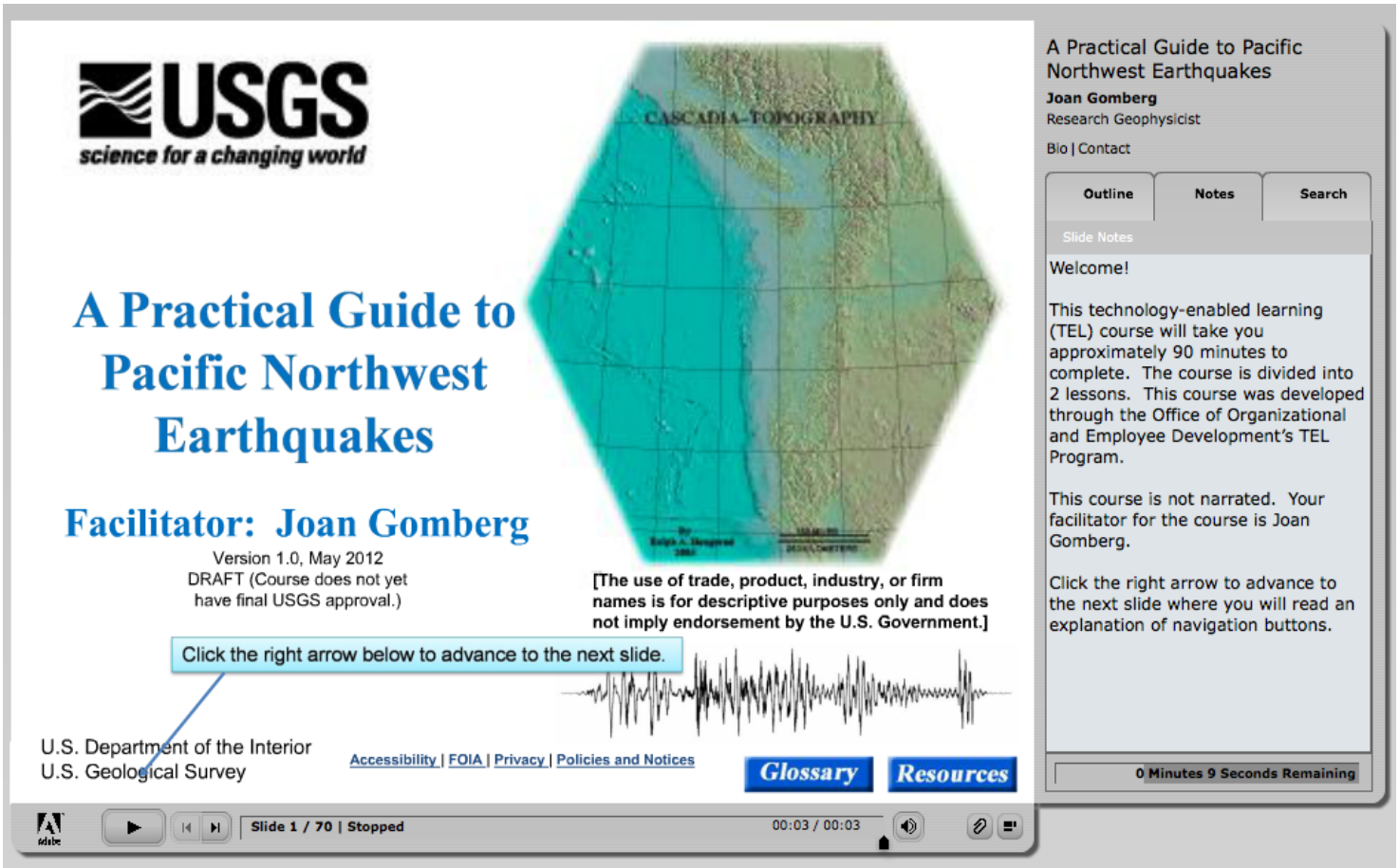


Figure 4. First page of online tutorial "A Practical Guide to Earthquakes". This tutorial was made available to all Evergreen Exercise participants prior to the Exercise, with one of the two lessons dedicated to information about EHP products. I can be viewed using any standard web browser.